

Claims

- [1] 1. A method comprising:
transforming a liquid into very small drops;
creating a droplet gas stream by surrounding the very small drops with a laminar flow of gas, said
droplet gas stream traveling at a first rate of speed and having a first width;
accelerating the droplet gas stream to a second rate of speed by narrowing the droplet gas stream to a second width, said second width being narrower than the first width and said second rate of speed being at a higher velocity than the first rate of speed;
directing the droplet gas stream traveling at the second rate of speed onto a refrigerant which is at least partially solidified.
- [2] 2. The method of claim 1 wherein said refrigerant is solid.
- [3] 3. The method of claim 1 wherein said refrigerant is undergoing sublimation.
- [4] 4. The method of claim 1 wherein said refrigerant is a slush comprising a mixture of solid and liquid.
- [5] 5. The method of claim 4 wherein said solid and liquids are the same element or compound.
- [6] 6. The method of claim 4 wherein said solid and liquids are different elements or compounds.
- [7] 7. A method comprising:
transforming a liquid into very small drops;
creating a droplet gas stream by surrounding the very small drops with a laminar flow of gas, said
droplet gas stream traveling at a first rate of speed and having a first width;
accelerating the droplet gas stream to a second rate of speed by confining the droplet gas stream to a second width, said second width being narrower than the first width and said second rate of speed being at a higher velocity than the first rate of speed;
directing the droplet gas stream traveling at the second rate of speed onto a refrigerant which is at least partially solidified;
rapidly freezing the very small drops portion of the droplet gas stream upon contact with the refrigerant creating very small frozen particles;
collecting the very small frozen particles from the refrigerant; and
directing the gas portion of the droplet gas stream away from the refrigerant.
- [8] 8. The method of claim 7 wherein said refrigerant is solid.
- [9] 9. The method of claim 7 wherein said refrigerant is undergoing sublimation.

- [10] 10. The method of claim 7 wherein said refrigerant is a slush comprising a mixture of solid and liquid.
- [11] 11. The method of claim 8 wherein said solid and liquids are the same element or compound.
- [12] 12. The method of claim 8 wherein said solid and liquids are different elements or compounds.
- [13] 13. The method of Claim 7 wherein after the very small frozen particles are collected from the refrigerant, the gas portion of the droplet gas stream is directed into a vacuum.
- [14] 14. A method comprising:
transforming a liquid into very small drops;
creating a droplet gas stream by surrounding the very small drops with a laminar flow of gas, said
droplet gas stream traveling at a first rate of speed and having a first width;
narrowing the droplet gas stream to a second width and accelerating the droplet gas stream to a second rate of speed by directing the droplet gas stream through a first open end of an open ended cone,
said open ended cone also having a second open end, the first open end and second open end each having a width, the width of the first open end being wider than the width of the second open end,
said second width of the droplet gas stream being narrower than the first width of the droplet gas stream and said second rate of speed being at a higher velocity than the first rate of speed;
directing the droplet gas stream traveling at the second rate of speed onto a refrigerant which is at least partially solidified.
- [15] 15. The method of claim 14 wherein said refrigerant is solid.
- [16] 16. The method of claim 14 wherein said refrigerant is undergoing sublimation.
- [17] 17. The method of claim 14 wherein said refrigerant is a slush comprising a mixture of solid and liquid.
- [18] 18. The method of claim 17 wherein said solid and liquids are the same element or compound.
- [19] 19. The method of claim 17 wherein said solid and liquids are different elements or compounds.
- [20] 20. A method comprising:
transforming a liquid into very small drops;
creating a droplet gas stream by surrounding the very small drops with a laminar flow of gas, said
droplet gas stream traveling at a first rate of speed and having a first width;

narrowing the droplet gas stream to a second width and accelerating the droplet gas stream to a second rate of speed by directing the droplet gas stream through a first open end of a first open ended cone,
said first open ended cone also having a second open end, the first open end and second open end each having a width, the width of the first open end being wider than the width of the second open end,
said second width of the droplet gas stream being narrower than the first width of the droplet gas stream and said second rate of speed being at a higher velocity than the first rate of speed;
narrowing the droplet gas stream to a third width and accelerating the droplet gas stream to a third rate of speed by directing the droplet gas stream through a first open end of a second open ended cone,
said second open ended cone also having a second open end, the first open end and second open end each having a width, the width of the first open end being wider than the width of the second open end,
said third width of the droplet gas stream being narrower than the second width of the droplet gas stream and said third rate of speed being at a higher velocity than the second rate of speed;
directing the droplet gas stream traveling at the third rate of speed onto a refrigerant which is at least partially solidified.

- [21] 21. The method of claim 20 wherein said refrigerant is solid.
- [22] 22. The method of claim 20 wherein said refrigerant is undergoing sublimation.
- [23] 23. The method of claim 20 wherein said refrigerant is a slush comprising a mixture of solid and liquid.
- [24] 24. The method of claim 23 wherein said solid and liquids are the same element or compound.
- [25] 25. The method of claim 23 wherein said solid and liquids are different elements or compounds.
- [26] 26. A method comprising:
transforming a liquid into very small drops;
creating a droplet gas stream by surrounding the very small drops with a laminar flow of gas, said
droplet gas stream traveling at a first rate of speed and having a first width;
narrowing the droplet gas stream to a second width and accelerating the droplet gas stream to a second rate of speed by directing the droplet gas stream through a first open end of a first open ended cone,
said first open ended cone also having a second open end, the first open end and second open end each having a width, the width of the first open end being wider

than the width of the second open end,
said second width of the droplet gas stream being narrower than the first width of the droplet gas stream and said second rate of speed being at a higher velocity than the first rate of speed;
narrowing the droplet gas stream to a third width and accelerating the droplet gas stream to a third rate of speed by directing the droplet gas stream through a first open end of a second open ended cone,
said second open ended cone also having a second open end, the first open end and second open end each having a width, the width of the first open end being wider than the width of the second open end,
said third width of the droplet gas stream being narrower than the second width of the droplet gas stream and said third rate of speed being at a higher velocity than the second rate of speed;
narrowing the droplet gas stream to a fourth width and accelerating the droplet gas stream to a fourth rate of speed by directing the droplet gas stream through a first open end of a third open ended cone,
said third open ended cone also having a second open end, the first open end and second open end each having a width, the width of the first open end being wider than the width of the second open end,
said fourth width of the droplet gas stream being narrower than the third width of the droplet gas stream and said fourth rate of speed being at a higher velocity than the third rate of speed;
directing the droplet gas stream traveling at the fourth rate of speed onto a refrigerant which is at least partially solidified.

- [27] 27. The method of claim 26 wherein said refrigerant is solid.
- [28] 28. The method of claim 26 wherein said refrigerant is undergoing sublimation.
- [29] 29. The method of claim 26 wherein said refrigerant is a slush comprising a mixture of solid and liquid.
- [30] 30. The method of claim 29 wherein said solid and liquids are the same element or compound.
- [31] 31. The method of claim 30 wherein said solid and liquids are different elements or compounds.
- [32] 32. A method comprising:
transforming a liquid into very small drops;
creating a droplet gas stream by surrounding the very small drops with a laminar flow of gas, said
droplet gas stream traveling at a first rate of speed and having a first width;
accelerating the droplet gas stream to a second rate of speed by narrowing the

droplet gas stream to a second width, said second width being narrower than the first width and said second rate of speed being at a higher velocity than the first rate of speed;

accelerating the droplet gas stream to a third rate of speed by narrowing the droplet gas stream to a third width, said third width being narrower than the second width and said third rate of speed being at a higher velocity than the second rate of speed;

directing the droplet gas stream traveling at the third rate of speed onto a refrigerant which is at least partially solidified.

[33] 33. The method of claim 32 wherein said refrigerant is solid.

[34] 34. The method of claim 33 wherein said refrigerant is undergoing sublimation.

[35] 35. The method of claim 34 wherein said refrigerant is a slush comprising a mixture of solid and liquid.

[36] 36. The method of claim 35 wherein said solid and liquids are the same element or compound.

[37] 37. The method of claim 35 wherein said solid and liquids are different elements or compounds.

[38] 38. A method comprising:

transforming a liquid into very small drops;

creating a droplet gas stream by surrounding the very small drops with a laminar flow of gas, said

droplet gas stream traveling at a first rate of speed and having a first width;

accelerating the droplet gas stream to a second rate of speed by narrowing the droplet gas stream to a second width, said second width being narrower than the first width and said second rate of speed being at a higher velocity than the first rate of speed;

accelerating the droplet gas stream to a third rate of speed by narrowing the droplet gas stream to a third width, said third width being narrower than the second width and said third rate of speed being at a higher velocity than the second rate of speed;

accelerating the droplet gas stream to a fourth rate of speed by narrowing the droplet gas stream to a fourth width, said fourth width being narrower than the third width and said fourth rate of speed being at a higher velocity than the third rate of speed;

directing the droplet gas stream traveling at the fourth rate of speed onto a refrigerant which is at least partially solidified.

[39] 39. The method of claim 38 wherein said refrigerant is solid.

[40] 40. The method of claim 38 wherein said refrigerant is undergoing sublimation.

- [41] 41. The method of claim 38 wherein said refrigerant is a slush comprising a mixture of solid and liquid.
- [42] 42. The method of claim 41 wherein said solid and liquids are the same element or compound.
- [43] 43. The method of claim 41 wherein said solid and liquids are different elements or compounds.
- [44] 44. An apparatus for freezing a stream of small liquid droplets, said apparatus comprising:
a source of gas flow attached to a freezing assembly;
said freezing assembly comprising:
a gas stream directional section having a first end connected to the source of gas flow and a second end connected to a laminar flow vane section,
said laminar flow vane section having a first end connected to the gas stream directional section and a second end connected to an accelerator section,
said accelerator section having a first end connected to the laminar flow vane section and a second end connected to a freezing section,
said freezing section comprising:
a target for the stream of small liquid droplets,
at least three radial gas collectors, said gas collectors being parallel with the target, and
a cryogen container and collector.
- [45] 45. The apparatus of claim 44 wherein the gas stream directional section has a telescoping variable length.
- [46] 46. The apparatus of claim 44 wherein the laminar flow vane section comprises:
a radial vane having at least three arms positioned inside a cylindrical tube, said cylindrical tube being connected at a first end to the gas stream directional section and a second end connected to the accelerator section.
- [47] 47. The apparatus of claim 44 wherein the accelerator section comprises:
a hollow cylinder with first and second ends corresponding to the first and second ends of
the accelerator section;
at least one opened ended cone positioned inside the hollow cylinder, said open ended cone having a first end and a second end, each end having a width, wherein width of the first end is wider than the width of the second end, the first end of the open ended cone positioned closer to the laminar flow vane section than the second end of the open ended cone; and
at least one spacing vane, said spacing vane being located between the at least one open ended cone and hollow cylinder.

- [48] 48. The apparatus of claim 44 wherein a flow filter is positioned between the source of gas flow and the freezing assembly.
- [49] 49. The apparatus of claim 44 wherein a humidifier is positioned between the source of gas flow and the freezing assembly.
- [50] 50. The apparatus of claim 44 wherein a control valve is positioned between the source of gas flow and the freezing assembly.
- [51] 51. The apparatus of claim 44 wherein a nebulizer is located between the gas stream directional section and the laminar flow section.
- [52] 52. The apparatus of claim 44 wherein a nebulizer is located within the laminar flow section.
- [53] 53. The apparatus of claim 44 wherein a nebulizer is located between the laminar flow section and the accelerator section.